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Does Pruning Reduce the Risk of Tree Failure?

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Arborists often confront requests from concerned clients such as, “Can you storm-proof my trees?” and, “Make that tree smaller, I’m worried it’s going to fall on my house during a hurricane!” Pruning is one of the most common arboricultural practices, yet we know very little about how it affects wind loading and tree failure. In the past, trees were topped and lion’s-tailed to “storm-proof” trees. Topped trees, the reasoning went, were smaller and therefore had less wind load. Because they had less of a sail area, lion’s-tailed trees were also believed to be less likely to fail—wind could just pass right through the canopy with all those leaves gone. Neither topping nor lion’s-tailing is good pruning, but we’ve reached that conclusion based on considerations of tree health, not because they didn’t reduce the risk of tree failure. Because so much foliage is removed, both topping and lion’s-tailing can reduce the tree’s ability to photosynthesize. Topping, in particular, also promotes decay where the topping cuts were made.

Recently, researchers have begun to examine how pruning affects wind loading of shade trees, and we’re just starting to understand this complicated interaction of wind and trees. Some common themes have been discovered, and future studies will hopefully shed more light on the subject. Here’s what we’ve learned so far.

Engineers and physicists call the force of the wind on a tree, “drag,” and the equation they use to predict drag shows that drag is related to several factors, the most important of which are the shape and area of an object and the wind speed. To demonstrate these factors, imagine standing on a tall building when the wind is blowing at 40 mph; you feel drag because your blocking the movement of air. You’d feel a lot more drag if the wind speed doubled, because drag is related to the square of wind speed. All other things being equal, if the

wind speed doubles, drag would increase by four times because $2^2 = 4$; if wind speed triples, then drag increases by nine times (3^2=9). Now imagine standing on the same building while you're holding an umbrella—you experience much more drag because your area has increased, and you block more air as it moves by. You may have scared a flying squirrel out of a tree you were pruning. The squirrel doesn't really fly, but it floats through the air and lands softly because it increased the drag on its body by extending its legs and exposing flaps of skin that increase its body area. The last main factor that affects drag is shape. We see evidence of why shape is important in the design of new cars, which have a streamlined profile. If two cars have the same area, but one has a more streamlined profile, it will experience less drag. This is one way that car manufacturers try to improve the fuel economy of their vehicles.

Since it's usually not practical to change the wind speed around trees, arborists are left to change the size and/or shape of a tree to reduce drag. Pruning obviously reduces the canopy area of a tree, and, intuitively, we expect that drag should be reduced. This is generally true, but it turns out that predicting how much drag will be reduced from the amount of canopy area removed is challenging. The main reason is that it's hard to measure the canopy area—it's not like a stop sign that has a well-defined shape. Taking digital photos can improve the measurement, but this requires expensive cameras, digital imaging software, and a clear background behind the tree. Even under the best circumstances, converting a three-dimensional object like a tree into a two-dimensional image skews the area measurements. The good news is that despite these complications, researchers have shown that tree weight is a good predictor of drag. The bad news is that it's not really practical to carry a scale around and weigh brush before feeding it to the chipper. In general, if you prune more (that is, remove more area or weight), you'll reduce drag more.

Pruning also changes tree shape, which affects 1) whether wind can flow freely through or around the canopy and 2) the center of pressure height. In general, if the canopy is more porous, it's easier for wind to flow through it. However, even if the canopy looks pretty open at low wind speeds, the reconfiguration of leaves and twigs often makes the canopy less porous at high wind speeds. There are very few studies that have carefully examined how air moves around (or through) an individual canopy for a good range of wind speeds, so this is something we need to understand better. Throw in the effect of pruning, and it becomes even harder to predict

what will happen. For example, we'd expect that reduction pruning doesn't really create a less porous canopy since it doesn't remove branches from the interior of the canopy. However, by reducing the length of the branches, reduction pruning increases the stiffness of those branches since they don't have as much leverage exerted on them. As a result, when leaves on the reduced branches begin to reconfigure, the canopy may become more porous than we expected. Thinning on the other hand may create a more porous canopy at low wind speeds, but as the wind speed increases and branches and twigs bend away from the wind, the canopy may become less porous, although its area is reduced. Understanding how air flows through the canopy is important, then, so we can figure out whether creating a more porous canopy is beneficial to reduce drag. You can see how complicated the interaction of wind and trees is, and we haven't even considered the dynamic effects of wind, which have only very recently been investigated.

Pruning can also change the center of pressure height, which effectively changes the leverage on the tree during a wind storm. Leverage is important because the same force that acts on a longer lever creates greater torque or bending than a force that acts on a shorter lever. Anyone who's used a rope to pull a tree as its being felled understands leverage: you don't set the rope a few feet above the notch because you won't get any leverage when you pull on the rope. Instead, you set the rope as high on the trunk as is safe and practical, which increases your leverage and allows one person to pull a tree that weighs many times more than they do. Of the common pruning types, reduction pruning reduces center of pressure height, since the canopy is shortened. On the other hand, raising increases the center of pressure height because only the lower branches are removed. Thinning doesn't really change the center of pressure height, according to the handful of studies that have looked at this question.

So, how does pruning affect wind loading and the likelihood of tree failure? The following recommendations must be taken cautiously, because 1) there are only a few studies that have examined this question, 2) the trees that have been tested have been relatively small, and small trees don't necessarily respond to wind the same way larger trees do, 3) winds have been generated artificially, which does not reflect real-world wind that is gusty, and 4) no dynamic analyses of pruning and the wind loading of shade trees have been undertaken. Of the three common pruning types from the ANSI A300 (Raise, Reduce, and Thin), reduction

pruning seems to do a better job at reducing drag and bending on trees, when the weight of foliage and twigs removed has been accounted for. Obviously, if you prune out more foliage and twigs, you'll reduce the drag more, but over-pruning adversely affects tree health. It is worthwhile noting, however, that when deciduous trees are not in leaf, they experience much less drag and bending, even more than fairly severe pruning. If you work in areas where winter storms are the most likely to cause tree failure, drastic pruning of deciduous trees might not be terribly effective at reducing the likelihood of failure. Raising has been the least effective pruning type, and this has been attributed mostly to the fact that raising increases the center of pressure height and increases leverage. So even though drag is reduced by raising, the increase in leverage offsets the reduction in drag and the tree still experiences a fair amount of bending. It's important to remember that leaves experience much more drag than twigs and branches. Consequently, pruning types that remove proportionally more foliage than branches will be more effective at reducing drag (again, in consideration of all the caveats mentioned above).

One last factor that has not been addressed in any studies yet is the long-term effects of pruning on re-growth of trees. Although reduction pruning has been more effective at reducing drag and bending, the tests were conducted on trees right after they were pruned. It's not guaranteed that the effect of pruning would be as beneficial once the tree begins to grow after pruning. Another area of research that is important, then, is investigating how different trees respond to different pruning types—which trees are most likely to sprout profusely after a particular pruning type, and under what conditions? For example, if reduction pruning causes excessive growth on some species, the possible benefits of pruning would only last for a short time.

Although researchers have started to attack the complicated issue of pruning and wind loads, we need to do much more research on pruning to understand all these factors better. We also need to start addressing the complex effects of gusty winds and swaying trees, which will help predict the likelihood of tree failure before and after pruning.

Further Reading

Kane, B. and E.T. Smiley. 2006. Drag coefficients and crown area estimation of red maple. Canadian Journal of Forest Research 36:1951-1958.

Kane, B., M. Pavlis, J.R. Seiler, and J.R. Harris. In Press, Canadian Journal of Forest Research. Crown reconfiguration and trunk stress in deciduous trees.

Pavlis, M. B. Kane, J.R. Harris, and J.R. Seiler. In Press, Arboriculture & Urban Forestry. The effect of pruning on drag-induced bending moment of shade trees.

Smiley, E.T. and B. Kane. 2006. The effects of pruning type on wind loading of *Acer rubrum*. Arboriculture & Urban Forestry 32:33-40.

Picks and Shovels

For more related information

For information on Mature Tree care, please visit the DCR Urban and Community Forestry fact sheets at: (http://www.mass.gov/dcr/stewardship/forestry/urban/urbanFAQs.htm#matureTrees)

Order the ANSI A300 pruning standard from the American National Standards Institute at: (http://webstore.ansi.org/?source=google&adgroup=ansi&keyword=ansi&gclid=CNTAnIPF9pECFU-oGgodQAht4g)

Growing Greener

Urban Forestry on WFCR - with assistance from a **DCR U&CF Challenge Grant** (http://www.mass.gov/dcr/stewardship/forestry/urban/urbanGrants.htm) the western Massachusetts public radio station WFCR will be broadcasting ten original stories on urban and community forestry in Massachusetts as part of its weekly natural history radio program, *Field Notes*. The Field Notes program reaches approximately 100,000 listeners weekly in western Mass, southern Vermont, New Hampshire and Connecticut. This project follows on to a similar successful series of programs that was funded in a previous year with a DCR urban forestry grant. To listen to the older Field Notes stories and learn more about the program in general, please visit (http://www.wfcr.org/field_notes/index.html)

Growing on Trees

National Arbor Day Announces the Theme for the 2008 Poster Contest "Trees are Terrific… Inside and Out!" Over 75,000 fifth grade classrooms and home schools across America participated in the 2007 Arbor Day National Poster Contest sponsored by Toyota. To receive free lesson plans that correlate with National Science and Art visit the NADF website: (www.arborday.org/kids/postercontest/index.cfm). For information about the Massachusetts contest, please contact Eric Seaborn at eric.seaborn@state.ma.us or 617-626-1468.

The Smart Growth Online website gives book suggestions and lists resources for smart growth by state (www.smartgrowth.org/default.asp). The **Smart Growth America** website provides additional information on smart growth by topic (www.smartgrowthamerica.org/).

"Urban Environments" is an informational e-mail resource to help municipalities and community organizations advance environmental justice, urban land conservation, brownfields to parks, and environmental

quality in cities throughout Massachusetts. To subscribe, contact Janet Curtis, Policy Coordinator for Environmental Justice and Urban Environments at the Executive Office of Energy and Environmental Affairs Email: (janet.curtis@state.ma.us)

On The Horizon

Green Cities: Lessons From Boston and Beyond, March 5, 2008, 8:30 a.m. to 11:30 a.m., Rabb Lecture Hall, Boston Public Library. Speakers include Boston Mayor Thomas Menino, Harvard University President Drew Gilpin Faust, and other distinguished presenters. For more information, go to (http://www.ksg.harvard.edu/rappaport/events/greencities.htm).

New England Flower Show An annual rite of spring and one of Boston's most enduring traditions, the New England Spring Flower Show has become the true symbol of spring's arrival for almost 100,000 winter-weary New Englanders and Boston visitors. The show is now in its 137th year and has grown to be the third largest flower show in the world. The region's most talented gardeners, designers and horticulturalists gather for nine days of breathtakingly beautiful exhibits, competitions, entertainment and information-sharing.
For more information please visit (http://www.masshort.org/New-England-Spring-Flower-Show)

Tree City USA –DCR's premier Urban and Community Forestry event, the annual ***Tree City USA Forum and Awards Ceremony*** will be held on Thursday May, 1st from 9am to 3pm at DCR's Elm Bank Reservation in Wellesley. Directions and other logistical dtiasl will follow soon. Once again, we will enjoy a key note address from a nationally known urban forestry specialist in the morning and recognize communities that have qualified for Tree City USA status in the early afternoon. **We will be notifying communities that have qualified for the award in the very near future. Please mark your calendar to reserve this date for this event.**

Important Reminder about Tree City USA Program Requirements – In order to receive the Tree City USA award, your community must conduct an Arbor Day ceremony and issue an Arbor Day proclamation each year. We urge you to use this requirement to the advantage of your community forestry programs by conducting a timely and well considered ceremony such as a tree planting at a local school in conjunction with the reading of the proclamation by local municipal leaders. This is just one of the many possibilities for recognizing and celebrating Arbor Day and bringing attention to the community forest and your efforts to protect and manage it with care.

2008 National Conference on Urban Ecosystems Nature and the Network: Building a new framework for people and nature to work together May 28 - 30, 2008 Caribe Royal Hotel Orlando, Florida. Organized by American Forests, the Conference will bring together members of the business, government and conservation communities, to solidify and expand partnerships, assess our progress and plan strategies for building communities of the future. (www.americanforests.org/conference)

Springfield to Host Green Spaces Forum April 4 The city, in cooperation with two area colleges, is conducting a one-day forum on April 4 that will focus on green space protection and enhancement. The event, titled "Springfield: Green City Forum," will be held at CityStage in downtown Springfield through a collaboration by the city, Western New England College and the University of Massachusetts **in Amherst. Read the MassLive.com story for details** (http://www.masslive.com/republican/stories/index.ssf?/base/news-13/1204532460218930.xml&coll=1) **or** For further information contact the Spirit of Springfield at (413) 733-3800.

Species Spotlight Hinoki Falsecypress (*Chamaecyparis obtusa*)

Hardiness Zone 5

Edible Tree Fruit: No

General Description: native to Japan evergreen with a narrow conical shape; spreading branches are pendulous; 50' to 75' in the landscape; 120' tall in the wild 10' to 20' wide; medium growth rate medium texture; appressed scale leaves of two varying sizes - the larger scale pair are boat-like with the smaller pair similar to a triangle; white X-like lines on underside of scales, dark green color

Culture: Prefers moist, loamy soil; needs a well-drained site; best in full sun; tolerates light shade

Landscape Use: mass plantings, specimen, dwarf forms used in rock gardens, foundation planting

Liabilities:. Does not do well in alkaline soil, does not transplant well

Cultivars/Varieties: **'Crippsii'**, **'Fernspray Gold'** and **'Gracilis Aurea'** - These forms are among the most common nursery selections with growth that is yellow or tipped yellow.

'Nana Gracilis'- The most common form of the species, very common in the trade and in gardens. Foliage is thick, dark green in color and arranged on "wavy" branches. Commonly used as a specimen or foundation planting. The habit is broad and conical, growing slowly to 6'-8'. The growth form may revert.

For more information on this and other tree species, see:

http://www.hort.uconn.edu/plants/index.html

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